U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
PB80-155443

Particulate Measurement-Evaluation of the Equivalency of the Three-Bag and Four-Bag LA-4 Dynamometer Test Procedures

(U.S.) Environmental Protection Agency, Ann Arbor, MI

Mar 79

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-AA-SDSB-79-15	2.	3. RECIPIENT'S ACCESSION NO. PB80 155443
4. TITLE AND SUBTITLE Particulate measurement-evaluation of the equivalency of the Three-Bag and Four-Bag LA-4 Dynamometer Test Procedures		5. REPORT DATE
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Danielson, Eugene		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Standards Development and Support Branch Emission Control Technology Division Office of Mobile Source Air Pollution Control U.S. Environmental Protection Agency Ann Arbor, MI 48105		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS		13. TYPE OF REPORT AND PERIOD COVERED Technical
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

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17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN-ENDED TERMS	c. COSATI Field/Group
Dynamometers Tests	Particulate measurements Light-duty diesel vehicles	

18. DISTRIBUTION STATEMENT RELEASE UNLIMITED	19. SECURITY CLASS (This Report) UNCLASSIFIED 20. SECURITY CLASS (This Page) UNCLASSIFIED	21. NO. OF PAGES 22. PRICE

EPA Form 2220-1 (9-73)

EPA-AA-SDSB-79-15

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by

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Office of Mobile Source Air Pollution Control
Office of Air, Noise and Radiation
U.S. Environmental Protection Agency

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NATIONAL TECHNICAL
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U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

Abstract

An evaluation of the equivalency of particulate measurements taken with the three-filter/cold-start/simulated hot-start (3-bag) dynamometer procedure and measurements taken with the two-filter/cold-start/hot-start (4-bag) dynamometer procedure has been completed. Two different light-duty diesel vehicles were used in this evaluation. Data from each of these vehicles indicate that the corrected mass of total suspended particulate material with either of the procedures are equal.

Introduction

Substantial concern was generated over the dynamometer procedure specified for particulate emissions in the "Draft Recommended Practice for Measurement of Gaseous and Particulate Emissions from Light-Duty Diesel Vehicles," issued in March, 1978. This document specified that a 4-bag LA-4 based driving cycle must be used for particulate measurements instead of the 3-bag LA-4 based driving cycle used for gaseous emissions measurements. The concern centered around the fact that this 4-bag procedure could be potentially costly not only because of the extra dynamometer time required, but also because it would require substantial computer reprogramming.

The exact procedure specified for particulate measurements consisted of a cold-start drive over the LA-4 cycle (first two bags) followed by a complete hot-start drive over the LA-4 cycle (second two bags). A single proportional particulate filter sample was taken during each LA-4 cycle so that the cold/hot FTP weighted particulate mass could be determined. This dynamometer procedure is referred to as the 2-filter/4-bag procedure, and is different from the common 3-bag dynamometer procedure used for gaseous emissions measurements in which the hot-start is simulated; i.e., the hot-start terminates after the first 505 seconds of the second LA-4 cycle (bag 3) because gaseous measurements that would have been taken during the remainder of the hot cycle (bag 4) are assumed to be identical to those taken during the same remaining period of the cold-start cycle (bag 2). A similar assumption for particulate emissions could not be made at the time the Recommended Practice was issued, and hence, the 2-filter/4-bag procedure was specified.

However, as noted previously, the 2-filter/4-bag procedure could be potentially costly, and therefore, it is desirable to sample particulates during a 3-bag FTP test. This 3-bag test would also have to be a three filter test (one for each bag) in order to properly weight each part of the cycle. This procedure is referred to as the 3-filter/3-bag procedure, and could only be used for diesel particulates if shown to be equivalent to the 2-filter/4-bag test.

Objective of Experiment

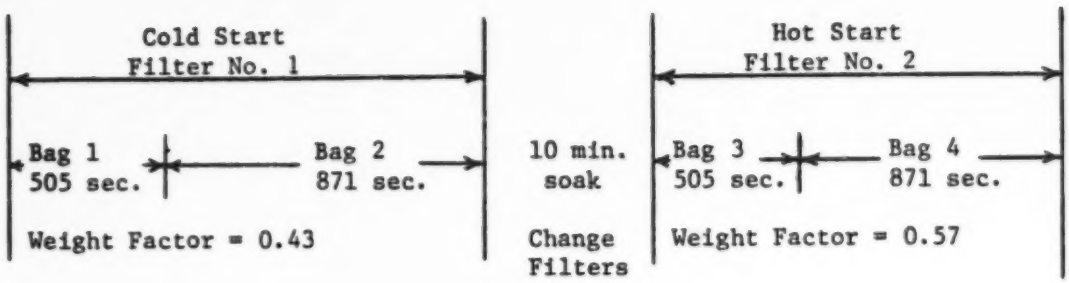
This study was conducted in order to evaluate the equivalency between the 2-filter/4-bag dynamometer procedure and the 3-filter/3-bag dynamometer procedure for light-duty diesel particulates.

Test Procedure

A specific particulate collection procedure was followed for determining the FTP weighted particulate mass for each dynamometer procedure. For the 2-filter/4-bag test, the sequence specified in the "Draft Recommended Practice for Measurement of Gaseous and Particulate Emissions from Light-Duty Diesel Vehicles" dated March, 1978, was followed. The important concepts of this procedure are diagrammed in Figure 1 below.

Figure 1

2-Filter/4-Bag Particulate Procedure

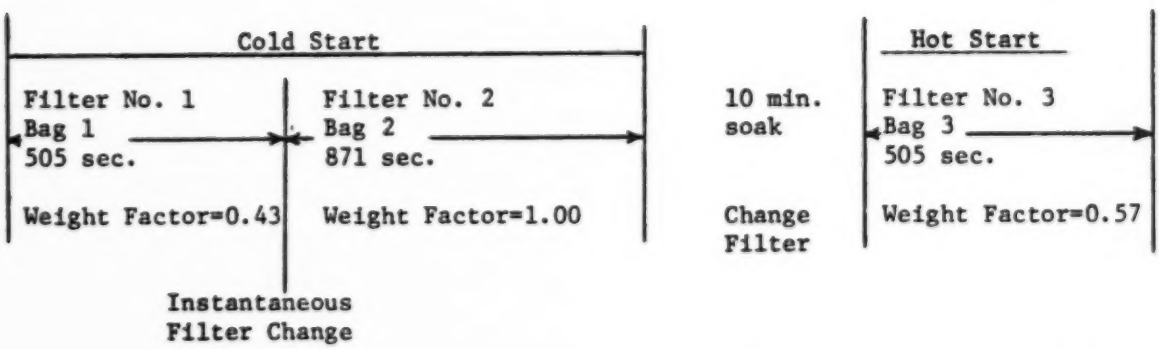


Weighted Mass = 0.43 x Net Weight of filter #1 + 0.57 x Net Weight of filter #2

In the 3-filter/3-bag test sequence, the above procedure was modified such that a filter was taken during each of the first three bag sample periods; the bag 4 sample was eliminated. In this sequence it is assumed that the particulate emissions that would have been measured during bag 4 is the same as that measured during bag 2. This results in a weighting factor for each filter that is identical to the corresponding bag weighting factor. The important concepts of this procedure are diagrammed in Figure 2 below.

Figure 2

3-Filter/3-Bag Particulate Procedure



Besides the test sequences described above, some other important factors should be noted with respect to the Test Procedure. In both sequences, particulates were collected by isokinetically removing a sample of exhaust from an 18 inch dilution tunnel. The sample was then passed through a 47 mm Pallflex filter (Teflon coated glass fiber) which

removed all of the particulate material. The weight of the particulate collected is considered to be the net weight difference between the clean filter, which has been stabilized with respect to humidity and temperature, and the loaded filter, which again has been stabilized with respect to humidity and temperature.

Results

Two different light-duty diesel vehicles were used in evaluating the equivalency of the dynamometer procedures. The individual FTP weighted particulate mass measurements for each vehicle and each procedure are presented in Table I attached. From this data it was concluded that the two dynamometer procedures are equivalent.

This conclusion was based on a test of the hypothesis that the average 3-filter/3-bag FTP weighted particulate mass was equal to the average 2-filter/4-bag FTP weighted particulate mass against the alternative that the particulate masses are unequal. The test was made at the 5% level of significance; i.e., if the procedures were equivalent, this would be determined with 0.95 probability. Moreover, if the procedures were unequal (i.e., differed by two standard deviations or more), the hypothesis would be rejected with the risk of making an incorrect decision not exceeding 0.15 with six samples. The criteria for acceptance of the hypothesis was met by both vehicles. Hence, it was concluded that the two dynamometer procedures are equivalent.

Attachment

ATTACHMENT

Table I

Dynamometer Test Procedure Evaluation
FTP Weighted Particulate Results ∿ Gm/Mi

Peugeot 504D		Oldsmobile 350D	
3-filter/3-bag	2-filter/4-bag	3-filter/3-bag	2-filter/4-bag
0.353	0.366	1.035	0.949
0.359	0.351	1.001	0.928
0.378	0.382	0.961	0.958
0.383	0.387	0.934	0.923
0.380	0.357	0.956	0.909
0.367	0.376	1.006	0.969
Ave. 0.370 (± 3.3%)	0.370 (± 3.9%)	0.982 (± 3.9%)	0.939 (± 2.4%)
Diff = 0.0%		Diff = 4.6%	